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Simulating collectivity in dense baryon matter with multiple fluids

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We present a novel multi-fluid approach to simulate heavy-ion collisions in the region of RHIC Beam Energy Scan and FAIR experiments. This region of collision energies from few to few tens of GeV is particularly interesting for the exploration of dense baryon matter and search of the critical point of QCD. However, fluid-dynamical modelling here poses notable challenges. Contraction of the incoming nuclei is much weaker, which results in a long inter-penetration phase and a complex initial-state geometry. Conventional hydrodynamic models, where the fluid phase starts at a fixed proper time $\tau 0$, therefore miss the compression stage of the collision. Hence, they miss the key sensitivity to the EoS of the dense medium.
In our approach [1], we circumvent this issue by representing the incoming nuclei as two cold, baryon-rich fluids with appropriate energy and baryon densities. The newly produced matter is represented by a third baryon-free fluid, which is generated by the friction between the two colliding fluids. Our MUlti Fluid simulation for Fast IoN collisions (MUFFIN) model is implemented from scratch using a versatile 3+1 dimensional relativistic viscous hydrodynamic code vHLLE. We present benchmark calculations for Au-Au collisions at different RHIC BES energies and discuss the challenges in constructing the approach.

[1] Jakub Cimerman, Iurii Karpenko, Boris Tomášik, and Pasi Huovinen, Phys. Rev. C 107, 044902 (2023)

Category

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